

Original Research Article

<https://doi.org/10.20546/ijcmas.2025.1405.011>

Chemical Control of *Sufetula anania* on Pineapple (*Ananas comosus* MD-2)

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ABSTRACT

In a commercial pineapple farm, two successive experiments were conducted to evaluate the effect of Rynaxypyr 20SC, Nemacur® 40EC and Mocap® 72EC on *Sufetula anania* control. In a block with the same propagative material and planting age, that was located at the edge of the mountain, where the pressure of the pest is greater, the experiments were established. The experiments were run in a Complete block design with three treatments and eight replicates. Each repetition was a terrace of 15 beds wide and 10-15 m long with 2000-2500 plants. In the first trial the following products were evaluated: Rynaxypyr 20SC 120 ml ha⁻¹, Rynaxypyr 20SC at 80 ml ha⁻¹ and Nemacur® 40EC 8 L ha⁻¹, each one plus 3 L of Agrex® F and all in 3750 L of water per hectare applied with spray boom, 68 days after planting. A second application was made on the same terraces, 33 days after the first application, but rotating the products. The treatment repetitions that ended with the highest pest incidence and pressure (Nemacur® 40EC 8 L ha⁻¹) was applied with Rynaxypyr 20SC at 100 ml ha⁻¹, those of Rynaxypyr 20SC at 80 ml ha⁻¹ were treated with Nemacur® 40EC at 10 L ha⁻¹ and those of Rynaxypyr 20SC at 120 ml ha⁻¹ were applied with Mocap® 72EC at 10 L ha⁻¹, each one of them, plus 3 L of Agrex® F and all in 3750 L of water per hectare applied with spray boom. To determine the performance of the products in pest control, monitoring was carried out in the first test, pre-application at 0, 10, 15, 23 and 31 days after the application and in the second, at 11, 18, 25 and 33 days after products were applied. In both tests, on the external line of the bed at the bottom of the terrace (border with mountain), 5 plants distributed along it were removed with a shovel and examined for the presence of *Sufetula anania*. Once the plants were examined, they were planted again and marked with colored spray paint, so that in the next sampling the evaluated plant was the neighbor and so on for the next samplings for both tests. That is, in each evaluation, there were 3 treatments (products) with 8 repetitions (8 terraces) and 5 plants on each terrace, for a total of 40 plants in each treatment and evaluation. In the first test, pre-treatment application (0 days), no differences were observed in the incidence (P= 0.4725) nor the number (P= 0.3831) of *Sufetula anania* by plant. The *Sufetula anania* incidence varied between 32.5 and 42.5% which means that from the 40 plants evaluated in each treatment between 13 and 17 had at least one larva present. The number of larvae oscillated between 1.2 and 1.7 by plant among treatments. Ten days after the treatments were applied, the incidence of root larvae differed (P= 0.0002) among products, being lower in plants treated with Rynaxypyr 20SC at 120 ml ha⁻¹ with 2.5%. Fifteen days after application, an even lower incidence of the pest was observed with all the products, but it increased, in all, after 23 days of application. The number of larvae per plant followed the same trend with reductions of 99 and 97% in the period of 10-15 days for the rate of 120 and 80-ml ha⁻¹ of Rynaxypyr, respectively, then the population began to increase. In the plants applied with Nemacur®, the population was diminished (P< 0.0001) by 87, 84 and 79% for the periods of 10-15, 10-23 and 10-31 days after its application, respectively. In the second test, a 95% reduction (P< 0.0001) in the incidence was observed 11 days after applying Rynaxypyr 20SC at 100 ml ha⁻¹ remaining such effect up to 25 days, and 92% (P= 0.0006) with the application of Mocap® 72EC at 10 L ha⁻¹ remaining the effect up to the 33 days post application. In the plants treated with Nemacur® 40EC at 10 L ha⁻¹ an 89% decrease was found 18 days after its application. Rynaxypyr 20SC at 100 ml ha⁻¹ reduced (P< 0.0001) the number of root larvae by plant by 96% 11 days after application, which remained low until 25 days after application. A very similar behavior was observed in the plants applied with Mocap® 72EC at 10 L ha⁻¹ where the reduction (P= 0.0004) was 94% at 11 days after application, remaining low with 0.02 per plant up to 25 days after application. In the plants treated with Nemacur® 40EC at 10 L ha⁻¹ a reduction of 90% was observed 18 days after application, such reduction was maintained up to 25 days and then started to increase. The results obtained show that Rynaxypyr 20SC was effective in controlling pineapple root larvae and that a rate of 120 ml per hectare should be used at high incidences and high population levels. Additionally, the effect of Mocap® 72EC in controlling the pest was confirmed and it was found that Nemacur® 40EC is another option for its control when both are used at the maximum rate registered on the label.

Keywords

Mocap®,
Nemacur®, pest
control, Rynaxypyr,
pineapple pest,
root pest

Article Info

Received:
05 March 2025
Accepted:
22 April 2025
Available Online:
10 May 2025

Introduction

Pineapples (*Ananas comosus* MD-2) are cultivated in Costa Rica for export markets. It is the second most important crop in Costa Rica after banana, with a planted area in 2023 of 53000 ha (CANAPEP, 2023), giving a total income in 2023 of US\$ 1175 million. Besides the demands and constraints of the pineapple market requirements, there are other factors limiting production.

Among the biotic factors constraining pineapple yield, root pests, like nematodes (*Pratylenchus brachyurus*, *Helicotylenchus* spp., *Meloidogyne* spp., *Rotylenchulus reniformis*), mealybugs (*Dysmicoccus brevipes*), symphylids (*Scutigerella immaculata*, *Hanseniellasp.*), snails (*Opeas pumilum*, *Cecilioides aperta*), white grubs (*Phyllophaga* spp.) are common and frequently found in the Costa Rican pineapple plantations (Rodríguez, 2011; Vargas, 2011; Garita, 2014; Guzmán *et al.*, 2014; Monge, 2018; Araya, 2019a; Ministerio de Agricultura y Ganadería- Servicio Fitosanitario del Estado, 2019).

Recently, Solis *et al.*, (2019), reported a new larva feeding on pineapple roots and associated weeds from Costa Rica and named it *Sufetula anania*. The same authors mentioned that its distribution in Costa Rica was southeast of San José, to the west of the Talamanca cordillera, and northwest of San José in the northern lowland's region, Buenos Aires, Puntarenas.

However, Cortes (2021) mentioned that since about 2017 the pest is present in all the pineapple areas of the country, which agrees with Cruz and Obando (2020) who mentioned that since 2005, damage symptoms induced by the pest, have been observed. We have talked with older pineapple technicians and field workers, and they indicated that it was first observed in that pineapple area around 2007 and spreading of the pest intensified in the last decade, and now it is found in all the pineapple producing counties of the country. Another species of *Sufetula* have been found parasitizing roots of ornamental palms in Florida (Hayden, 2013), palms in Indonesia (Bonneau *et al.*, 2004, 2007), sugarcane in Puerto Rico (Seín, 1930; Solis and Shaffer, 1999).

The larvae attack immature roots (that appear to be almost the diameter of the larvae) of the plant at all ages, since root emission up to fruit harvest, either in the plant crop or ratoon crop. *Sufetula anania* incidence begins soon after root emission especially in the dry season expressing its greatest affectation in the driest month;

however, the pest remains active (Méndez, 2024) and causes problems all year around. The larvae tunnel the roots and reduces its mass, leading to a reduction in the assimilation of water and nutrients, which conduce inhibition of growth, chlorosis, yellowing, necrosis of leaf tips and gummosis in the stem, so the age to force is prolonged, yield is reduced for plant crop and ratoon crop, increasing the number of small fruits.

Due to the wounds on the roots, plant susceptibility to *Fusarium* and *Phytophthora cinnamomi* increases and frequently up to 90% affectation is observed, likewise the incidence of plants with *Ralstonia solanacearum* increases. In the second harvests, plant overturning increases markedly, especially those that are on the edges of the terrace and in seedbeds there are less shoot emission and seed availability.

The pineapple grower practice is to start monitoring the pest 30 days after planting on those plants on beds close to the mountain and primary channels edges and applied control options when the incidence exceeds 15% or the number of larvae exceeds 0.2 by plant.

Rynaxypyr is a specific systemic insecticide for lepidoptera (Cline, 2007; Lahm *et al.*, 2007, 2009; Cameron *et al.*, 2015) that belongs to the group 28 of the anthranilic diamides class (Lahm *et al.*, 2007; Teixeira and Andaloro, 2011). It is a potent ryanodine receptor activator leading to the uncontrolled release of intracellular calcium located in the muscle cell sarcoplasmic reticulum and non-muscle cell endoplasmic reticulum which is stored critically for muscle contraction. It is characterized by its high insecticidal activity and low toxicity to mammals. Its name is derived from the natural insecticide ryanodine, a metabolite from the *Ryania speciosa* plant (Rogers *et al.*, 1948; Lahm *et al.*, 2009) that affects calcium release by blocking partially open channels.

The effectiveness of Rynaxypyr for the control of lepidoptera in different crops such as pineapple (Herrera *et al.*, 2024a), sugarcane (Jasmini *et al.*, 2012), cabbage (Cameron *et al.*, 2015), *Vigna radiata* (Sujayanand *et al.*, 2021), have been documented. The ability of insects to rapidly develop resistance to conventional insecticides is a problem in effective pest management. The incorporation of new insecticides that work on new biochemical mechanisms is an option for effective pest control and contributes to crop protection. Then, knowing that *Sufetula anania* is a lepidopteran (Solis *et*

al., 2019) that attacks the pineapple root system, it was again studied the effectiveness of the commercial application of Rynaxypyr on its control compared with other insecticides commercially applied for the control of other pineapple pests.

Materials and Methods

Two experiments were developed consecutively in the same area within a long-term (more than 10 planting cycles) commercial pineapple plantation located at Los Chiles county, in the Alajuela province at an altitude of 40-50 meters above sea level, Costa Rica. The soil was cleaned free of plant residues and weeds, plowed four times, the first two times in cross (+) to a depth of 40-50 cm and then the other two times in equix (x) to a depth of 70-75 cm, followed by four passes of disk harrowing and then ripped to 100 cm depth.

Between the passes of dish harrowing 1500 kg of dolomite lime (35% CaO and 16% MgO Agricultura Ecológica Carbonatos y Abonos) were applied and incorporated with the harrow. The plantation layout was on terraces of 15 beds wide and 10-15 m long with about 2000 to 2500 plants. Beds were formed one month before planting. The Inceptisol soil presented a clay loam texture (28% sand, 34% silt and 38% clay), with an organic matter content of 2.0% and a pH of 5.5.

The plantation had a system of primary, secondary and tertiary drainage channels to eliminate excess rainwater and avoid waterlogging conditions during heavy rains. Manual planting was carried out with suckers between 400-500 g of *Ananas comosus* cv. MD-2 at a planting density of 67000 plants ha⁻¹. The first application of the treatments was carried out 68 days after planting when the incidence of the pest was greater than 30% and the population was equal to or greater than 1.2 larvae of *Sufetula anania* by plant. The experimental period was between July and September 2023. The monthly precipitation was 74.8; 101.9 and 151.8 mm for the months of July, August and September 2023, respectively. The average daily maximum and minimum temperature varied between 26.7 and 27.8 °C and between 24.1 and 24.6°C, respectively.

Following bed conformation, the pre-emergent solution: Bioquin Oxiflu 24EC (Oxifluorfen-UPL OpenAG™) 5 L ha⁻¹ in 2000 L of solution ha⁻¹ was applied to control weeds before planting and after sowing with a mixture of Diurex® 80 WG (diuron-Adama) 2 L ha⁻¹ + Ametrine

500SC (ametrine-Adama) 2 L ha⁻¹ + clethodim® 240EC (Cletodima-Agrospec) 2 L ha⁻¹ all in 2000 L solution ha⁻¹ and sometimes with Galant® Plus 12EC (Haloxypol methyl 12% Dow AgroSciences) 1 L ha⁻¹ or Fusilade 12.5EC (Fluazifop-P-Butyl Syngenta) 1.5 L ha⁻¹ in 2000 L of solution ha⁻¹.

Fifteen days after planting and then every 15 days, a mixture of nutrients was foliar applied in 2000 L of water with a spray boom at a rate adapted to the needs of the soil and the crop to complete 700 kg N, 300 kg P₂O₅, 450 kg K₂O, 200 kg MgO, 12 kg Cu and 40 kg Zn per hectare for the crop cycle. The diseases were managed with applications of systemic and protective fungicides. These management practices (weed control, fungicide and fertilizer applications) were applied uniformly on all terraces.

Prior to the treatment application, no insecticides or insecticide-nematicide was applied. The treatments evaluated were: 1: Rynaxypyr 20SC 120 ml ha⁻¹, 2. Rynaxypyr 20SC 80 ml ha⁻¹, and 3. Nematicur® 40EC (phenamiphos-AMVAC) 8 L ha⁻¹. Rynaxypyr 20SC was applied in solutions with 3 L of Agrex® F (adjuvant, penetrant, dispersant, humectant and antifoam-Agroenzimas) and all product solutions in 3750 L of water per hectare. Given the highest pressure, we were not allowed to set up untreated control. The experiment was established in a block bordered by mountains with abundant cover, a refuge for the pest (Herrera *et al.*, 2024b). The rectangular terraces (plots) were arranged in a Random Complete Block Design with 3 treatments and 8 repetitions.

The application was carried out with a spray boom with TeeJet 6508 nozzles with a discharge of 3.17 L per minute attached to a Landini Land Power 145 tractor at a speed of 1.5 km per hour in first gear and at 1600 rpm. The treatment application order was: first Rynaxypyr 20SC and lastly Nematicur® 40EC. After the application of each product solution, the boom (tank and nozzles) was washed.

To determine the products performance, pest sampling was carried out pre-application at 0 days and then 10, 15, 23 and 31 days after the products were applied. As in all the applied terraces their bottoms were bordered by mountains with abundant coverage, sampling was done on the external line of the last bed at the bottom of the terrace. Pest sampling was carried out in five plants along the bed in each plot and sampling. Plants were removed

with a shovel and shaken onto a black plastic cover, and in each the soil and the plant were examined for the presence of the pest. Once the plants were examined, they were planted again and marked with colored spray paint, so that in the next sampling, the plants evaluated were the neighbor and so on during the 5 sampling times.

That is, in each evaluation there were 3 treatments (products) with 8 repetitions (8 terraces) and 5 plants on each terrace, for a total of 40 plants in each treatment and evaluation. Then, the incidence of *Sufetula anania* per plant and terrace was determined and recorded. The presence of one or more larvae in any plant means incidence of the pest and non-detection of the pest in the plant indicates that there was no incidence. The percentage of incidence was calculated as follows: number of plants with the presence of the pest divided by the total number of plants evaluated per terrace (5) \times 100.

The incidence and population of *Sufetula anania* were subjected to ANOVA at evaluation 0; subsequently, the evaluations within each treatment were subjected to ANOVA and mean separation by LSD using the linear mixed models' approach where the fixed effect of treatment or evaluation and the random effect of the block were declared in the model. To compare the treatment effect, the average of the evaluations at 10-15, 10-15-23 and 10-15-23-31 days post-application was subjected to ANOVA and means separation by LSD. The product effect was determined by contrasts comparing the variables mean of the pre-application (evaluation= 0) in each treatment against the global means after application, evaluations at 10-15, 10-15-23 and 10-15-23-31 days after application.

As was expected, 23 days after the products application an increase in the pest incidence was observed in all treated plants since it is known that Rynaxypyr have a residual control of up to three weeks (FMC, 2025). Then a second application was made two days after the last evaluation of the first experiment, in the same repetitions but changing the products. The objective was to verify the control offered by Rynaxypyr and to evaluate the highest rate indicated on the label of other products registered for pest control in the crop. The changes and new treatments are indicated in Table 1.

Rynaxypyr 20SC was tested at the intermediate rate of 100 ml ha⁻¹ and Nemacur® 40EC and Mocap® 72EC (ethoprophos-AMVAC) at the maximum rate registered on the label of 10 L ha⁻¹. The treatment application order

was: first Rynaxypyr 20SC, second Nemacur® 40EC and then Mocap® 72EC. After the application of each product solution, the boom (tank and nozzles) was washed. To monitor the pest the same procedure used in Experiment I was followed, sampling 5 plants per terrace in each evaluation at 11, 18, 25 and 33 days after applying the products. In the statistical analysis the same approach followed in Experiment I was applied, using the data of the last evaluation of Experiment I as the pre-application data of the products for experiment II.

Results and Discussion

Experiment I

When the *Sufetula anania* incidence was analyzed among evaluations (0, 10, 15, 23, 31 days) within each treatment, a significant ($P < 0.0001$) reduction was observed in the plants of the three treatments (Figure 1A). In the plants applied with Rynaxypyr at 120 ml ha⁻¹ the incidence pre-application of 42.5% was reduced to 2.5 and 0.0% at 10 and 15 days after application, respectively, and then start to increase reaching 32.5% at 31 days after application.

In the plants treated with Rynaxypyr at 80 ml ha⁻¹ the incidence pre-treatment of 40% was reduced to 2.5% 10 days after the product was applied and starts to increase 15 days after the application reaching 22.5% at 31 days after plants were treated. For the plants applied with Nemacur® the incidence pre-treatment of 32.5% was reduced more slowly up to 15 days after treatment with 12.5% and then began increasing reaching 50% at 31 days after treatment.

A similar behavior was observed in the number of *Sufetula anania* by plant where in all treatments there were differences ($P \leq 0.0026$) among evaluations (Figure 1B). Plants treated with Rynaxypyr at 120 ml ha⁻¹ the population of 1.4 by plant pre-application was reduced to 0.0 by plant at 10 and 15 days after treatment and hereafter starts to increase.

A similar trend was observed on the plants treated with Rynaxypyr at 80 ml ha⁻¹ where the pre-treatment population of 1.2 larvae by plant was reduced to 0.0 and 0.1% at 10 and 15 days after product application and then began to increase. In the plants treated with Nemacur® the population pre-application of 1.7 by plant was decreased to 0.3 and 0.2 by plant at 10 and 15 days after its application and then started to increase.

Pre-treatment application (0 days), no differences were observed in the incidence ($P = 0.4725$) nor the number ($P = 0.3831$) of *Sufetula anania* by plant (Figure 2A-B). The *Sufetula anania* incidence varied between 32.5 and 42.5% which means that from the 40 plants evaluated in each treatment between 13 and 17 had at least one larva present. The number of larvae oscillated between 1.2 and 1.7 by plant among treatments. When the treatment effect was analyzed comparing the global means of the periods of 10-15, 10-23 and 10-31 days after product application, in the three periods there were differences ($P \leq 0.0256$) among treatments in the incidence (Figure 2A). The higher incidence in the three periods was found in those plants treated with Nemacur® with 16.3, 17.5 and 25.6%, while in the rates of Rynaxypyr the incidence was statistically lower and similar for 120- and 80-ml ha⁻¹ with 1.3 and 3.8; 5.8 and 5.8; and 12.5 and 10%, respectively, for the analyzed periods. In the number of larvae by plant, only in the period of 10-15 days was the population higher ($P = 0.0122$) in the plants treated with Nemacur® with 0.23 by plant compared with 0.01 and 0.04 by plant in those treated with the 120- and 80-ml ha⁻¹ of Rynaxypyr (Figure 2B). In the other two periods, 10-23 ($P = 0.5250$) and 10-31 days ($P = 0.9791$), the number of larvae by plant was similar ($P \geq 0.5250$) and varied between 0.28 and 0.30, and between 0.31 and 0.36 by plant, respectively.

Regarding the product effect, comparison by contrasts of the incidence and population by plant of *Sufetula anania* before product application vs the global means of the periods of 10-15, 10-23 or 10-31 days after application, in the plants treated with Rynaxypyr either at 120- or 80-ml ha⁻¹ in the three periods of both rates, the incidence was reduced ($P < 0.0001$). In both rates, the lowest incidence was found in the period of 10-15 days with 1.3 and 3.8% increasing to 5.8% for both rates in the period of 10-23 days and continuing increasing up to the period of 10-31 days post application (Figure 3A). Similar trends were observed in the number of *Sufetula anania* by plant (Figure 3B). In the three periods with both Rynaxypyr rates the population was reduced ($P < 0.0440$). The highest reduction was found in the period of 10-15 days with 99 and 97% for the rate of 120 and 80-ml ha⁻¹ of Rynaxypyr, respectively, then the population began to increase, becoming larger as the period analyzed lengthened. The same trend was observed in the plants applied with Nemacur®, where in the three analyzed periods also the population was diminished ($P < 0.0001$) by 87, 84 and 79% for the periods of 10-15, 10-23 and 10-31 days after its application, respectively.

Experiment II

When the *Sufetula anania* incidence was analyzed among evaluations (0, 11, 18, 25, 33 days) within each treatment, a significant reduction was observed in the plants treated with Rynaxypyr ($P < 0.0001$) and Mocap® 72EC ($P = 0.0472$). In plants applied with Rynaxypyr at 100 ml ha⁻¹ the pre-application incidence of 50% was reduced to 2.5% (95%) at 11, 15 and 25 days, and then increased to 5% 33 days after application, while in those treated with Mocap® the pre-application incidence of 32.5% was reduced to 2.5% (92%) for all the evaluations (Figure 4A). Although a reduction from 22.5% up to 2.5% (89%) was observed in the plants applied with Nemacur® 40EC, the difference was not large enough to be significant ($P = 0.0877$).

A similar behavior was observed in the number of *Sufetula anania* by plant where in the plants treated with Rynaxypyr ($P < 0.0001$) and Mocap® ($P = 0.0001$) the population pre-application was reduced from 0.6 to 0.03 (96%) at 11, 18 and 25 days and from 0.4 to 0.03 (94%) at 11, 18, 25 and 33 days after application, respectively (Figure 4B). In the plants treated with Nemacur® even though the population pre-application of 0.5 was diminished up to 0.03 (95%) the difference was not significant ($P = 0.2554$).

Pre-treatment application, no differences were observed in the incidence ($P = 0.0928$) nor the number ($P = 0.7537$) of *Sufetula anania* by plant (Figure 5A-B). The *Sufetula anania* incidence varied between 22.5 and 50.0% which means that from the 40 plants evaluated in each treatment between 9 and 20 had at least one larva present. The number of larvae oscillated between 0.43 and 0.60 by plant among treatments. When the treatment effect was analyzed comparing the global means of the periods of 11-18, 11-25 and 11-33 days after product application, in all of them the incidence was similar ($P \geq 0.4001$) among treatments (Figure 5A), which means that all had equal effect. The incidence varied between 2.5 and 8.8; between 2.5 and 6.7 and between 2.5 and 6.3% for the periods of 11-18, 11-25 and 11-33 days after product application, respectively, and always the highest incidence was in the plants treated with Nemacur®. Alike response was observed in the number of larvae by plant, where in all periods it was similar ($P \geq 0.3317$), meaning that all products had similar effect, with the highest population in the three periods in those plants treated with Nemacur® (Figure 5B). In plants treated with Rynaxypyr and Mocap® the population pre-

application of 0.60 and 0.43 by plant was reduced to 0.03 (96 and 94%) in plants of both treatments for the period of 11-18 days and remain with the same population up to the period of 11-33 days post application.

When the product effect was analyzed, comparison by contrasts of the *Sufetula anania* incidence pre-application vs the global means of the periods of 11-18, 11-25- or 11-33-days post application, in the plants treated with Rynaxypyr, in the first two periods the incidence was reduced ($P < 0.0001$) from 50% to 2.5% (95%) for the periods of 11-18 and 11-25 days, and then increased to 3.1% for the period of 11-33 days post application (Figure 6A). In plants treated with Mocap®, the pre-application incidence of 32.5% was reduced ($P = 0.0034$) to 2.5% (92%) for the period of 11-18 days, which was maintained until the period of 11-33 days post-application.

Although in the plants treated with Nemacur® the pre-application incidence of 22.5% was reduced to 6.3% (72%) for the period of 11-33 days post-application, in none of the periods was significant ($P \geq 0.2486$). Similar trends were observed in the number of *Sufetula anania* by plant (Figure 6B). In the three periods, with Rynaxypyr the population was reduced ($P < 0.0001$) from 0.60 to 0.03 by plant which corresponds to 95.8% reduction. In plants treated with Mocap® the population was reduced ($P < 0.0001$) by 94% for the three periods, from 0.43 pre-application to 0.03 per plant. Even though, in the plants treated with Nemacur® the initial population of 0.45 by plant diminished by 28, 50 and 60% for the periods of 11-18, 11-25 and 11-33 days after its application, respectively, such reductions were not significant ($P \geq 0.2886$).

In both experiments, pre-application of the treatments, a high incidence of *S. anania* was observed in the entire experimental area, varying between 32.5 and 42.5% and between 22.5 and 50.0% of plants infested, with a population between 1.2 and 1.7 and between 0.43 and 0.60 by plant for experiment I and II, respectively.

Before, growers were applying control options when the incidence on the plants exceeds a critical level between 10 and 25% (Herrera et al., 2024a). Today the practice is to applied control options based either on the incidence lower than 15% or a threshold of less than 0.2 larvae by plant in the monitoring given the rapid multiplication cycle of the pest of between 57 and 70 days (Cruz and Obando, 2020; Méndez, 2024).

In the two experiments Rynaxypyr at the evaluated rates reduced significantly, below the economic threshold the incidence of the pest up to 31 and 33 days after its application in agreement with that reported by Herrera et al., (2024a) who found good control up to 28 days after its application. Considering the population by plant, the Rynaxypyr application reduced significantly, below the economic threshold the population of the pest up to 15 days, in the first experiment, and with the second application of other insecticide, either Mocap® or Nemacur®, the control was extended up to 33 days, time that the experiment lasted.

Positive results with the application of Rynaxypyr were reported by Bacca et al., (2021) who obtained 100% mortality of initial larval stages of *Tecia solanivora* (Lepidoptera) in potato tubers. In this experiments, a very good control was observed in the first evaluation at 10 (Exp I) and 11 days (Exp II) post application, which is in parallel with the results of Sujayanand et al., (2021) who found reduction of the Lepidoptera *Helicoverpa armigera* and *Spodoptera litura* one day after the application on *Vigna radiata*, reaching the maximum reduction at 3 and 7 days after the application. According to Cordova et al., (2006) and Hannig et al., (2009), in the treated larvae there is an immediate cessation of feeding, paralysis, lethargy and regurgitation. Its rapid action occurs because 7 minutes after the pest encounters the product, it becomes paralyzed and stops feeding (Cline, 2007).

The *Sufetula anania* control observed with Mocap® 72EC at 10 L ha⁻¹ confirms that reported by Cruz and Obando (2020), who found high toxicity of the product for *Sufetula anania* L-3 and L-4 stages. The control observed with Mocap 72EC was statistically equal to that of Rynaxypyr on *Sufetula anania* incidence as well in the population by plant. These would be the first *Sufetula anania* control reported with commercial application of Mocap® 72EC in pineapple plantations. In the case of Nemacur® 40EC, good pest control was observed up to 18 days after application, but at the maximum rate recorded on the label of 10 L ha⁻¹. This later control may be related to the basipetal and acropetal systemic movement of the product (Zeck, 1971; Flint, 1977) which is absorbed by both the roots and the foliage, so contact between the pest and the active ingredient most likely occurs until the pest feeds on the roots. Both products Mocap® 72EC and Nemacur® 40EC mode of action is on the pest's nervous system (Roberts and Hutson, 1999; Devine et al., 2008).

Table.1 Description of the treatments evaluated in each experiment in the same experimental area of pineapple (*Ananas comosus* MD-2) for *Sufetula anania* control.

Treatments: Experiment I	Treatments: Experiment II
1. Rynaxypyr 20SC 120 ml ha ⁻¹	1. Mocap® 72EC 10 L ha ⁻¹
2. Rynaxypyr 20SC 80 ml ha ⁻¹	2. Nemacur® 40EC 10 L ha ⁻¹
3. Nemacur® 40EC 8 L ha ⁻¹	3. Rynaxypyr 20SC 100 ml ha ⁻¹

Figure.1 A-B. A) Incidence (%) and B) number of *Sufetula anania* by plant of pineapple (*Ananas comosus* MD-2) in different sampling times after treatment with different products for its control. Each bar is the mean \pm standard error of 8 repetitions and in each repetition 5 plants were evaluated. The probability over each group of bars compares the evaluations within each treatment and the letters correspond to the mean separation by LSD.

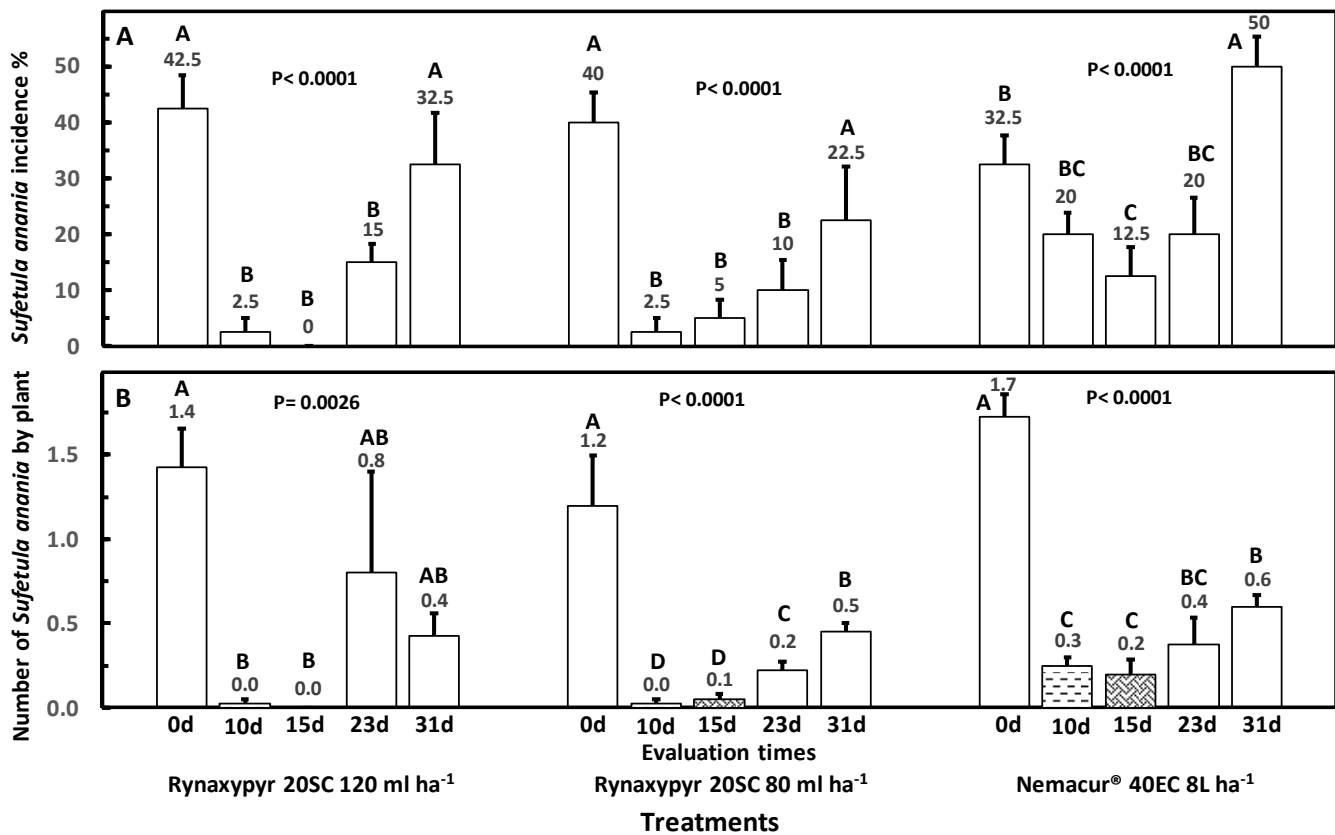


Figure.2 A-B. A) Incidence (%) and B) number of *Sufetula anania* by plant of pineapple (*Ananas comosus* MD-2) pre-application and post treatment with different products for its control. Pre-application 0 days: each bar is the mean \pm standard error of 8 replicates, x 10 -15 days: each bar is the mean \pm standard error of 16 observations (two evaluations at 10 and 15 days and 8 replicates in each evaluation), x 10 -23 days: each bar is the mean \pm standard error of 24 observations (three evaluations at 10, 15 and 23 days and 8 replicates in each evaluation) and x 10 -31 days: each bar is the mean \pm standard error of 32 observations (four evaluations at 10, 15, 23 and 31 days and 8 replicates in each evaluation). In each replicate, five plants were evaluated. The probability over each group of bars compares the treatments and the letters correspond to the mean separation by LSD.

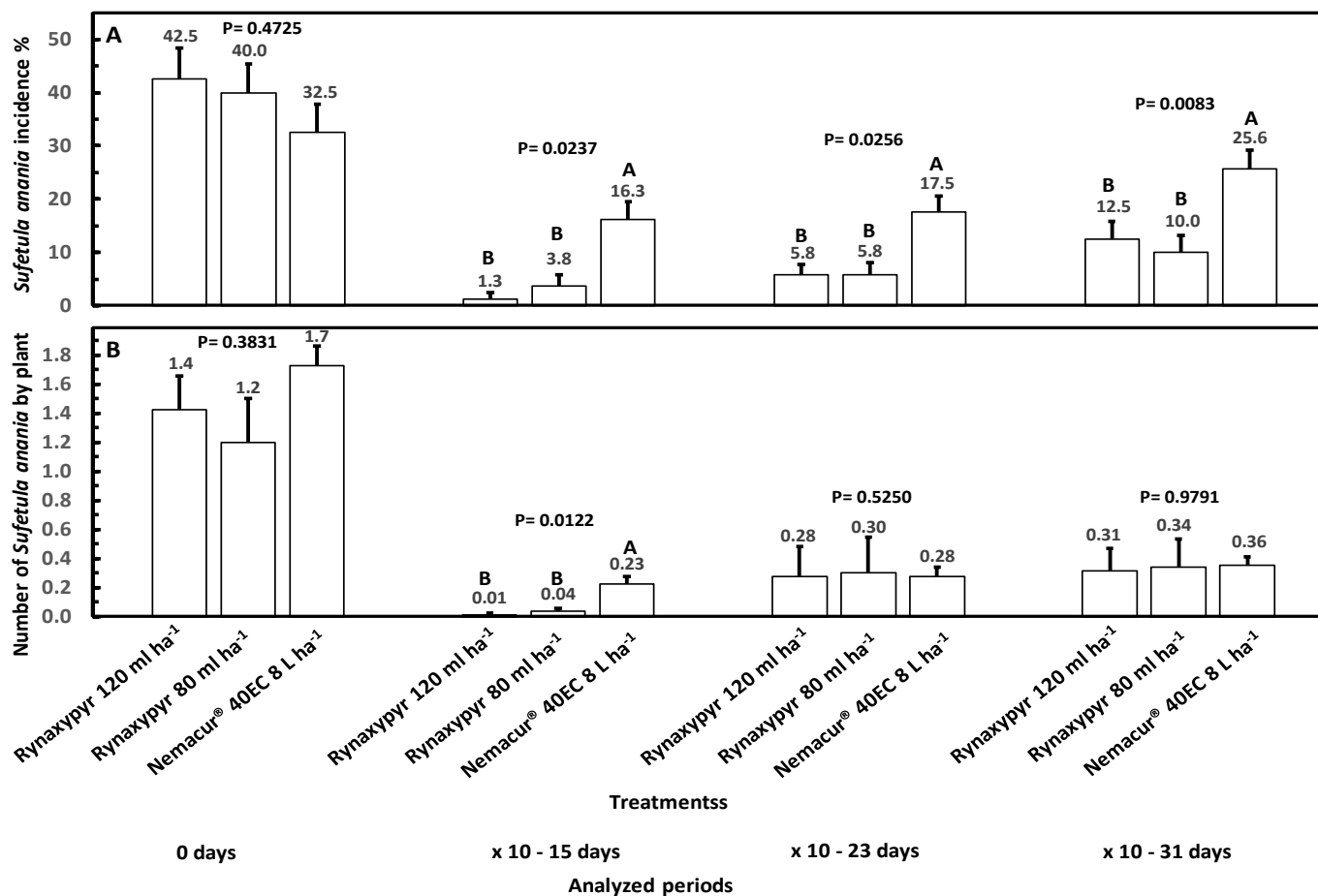


Figure.3 A-B. Product effect (pre-application comparison versus average of evaluations at 10-15; 10-15-23 days or average of evaluations at 10-15-23-31 days post application) on the incidence (A) and (B) number of *Sufetula anania* by plant of pineapple (*Ananas comosus* MD-2) that were treated with different products. At 0 days (0d) each bar is the mean \pm standard error of 8 repetitions, at x10-15d, which is the average of 10 and 15 days post application, each bar is the mean \pm standard error of 16 observations (2 evaluations at 10 and 15 days post application * 8 repetitions), at x10-23d, which is the average of 10, 15 and 23 days post application, each bar is the mean \pm standard error of 24 observations (3 evaluations at 10, 15 and 23 days post application * 8 repetitions) and at x10-31d, which is the average of 10, 15, 21 and 31 days post application, each bar is the mean \pm standard error of 32 observations (4 evaluations at 10, 15, 23 and 31 days post application * 8 repetitions) and in all evaluations, in each repetition the value is the average of 5 plants. The probability over the x10-15d, x10-23d and x10-31d bars correspond to the comparison of that average against the value at 0 days in each treatment.

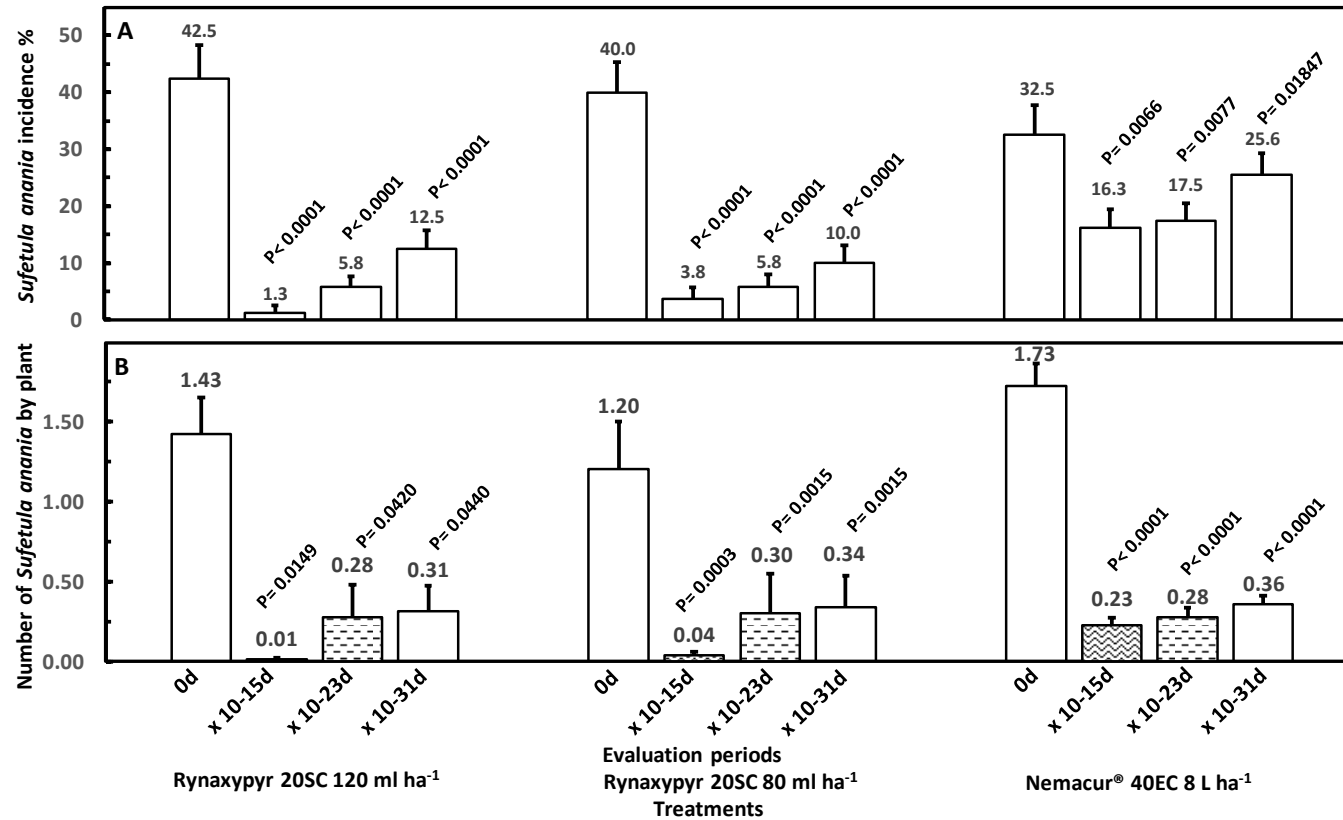


Figure.4 A-B. A) Incidence (%) and B) number of *Sufetula anania* by plant of pineapple (*Ananas comosus* MD-2) in different sampling times after treatment with different products for its control. Each bar is the mean \pm standard error of 8 repetitions and in each repetition 5 plants were evaluated. The probability over each group of bars compares the evaluations within each treatment and the letters correspond to the mean separation by LSD.

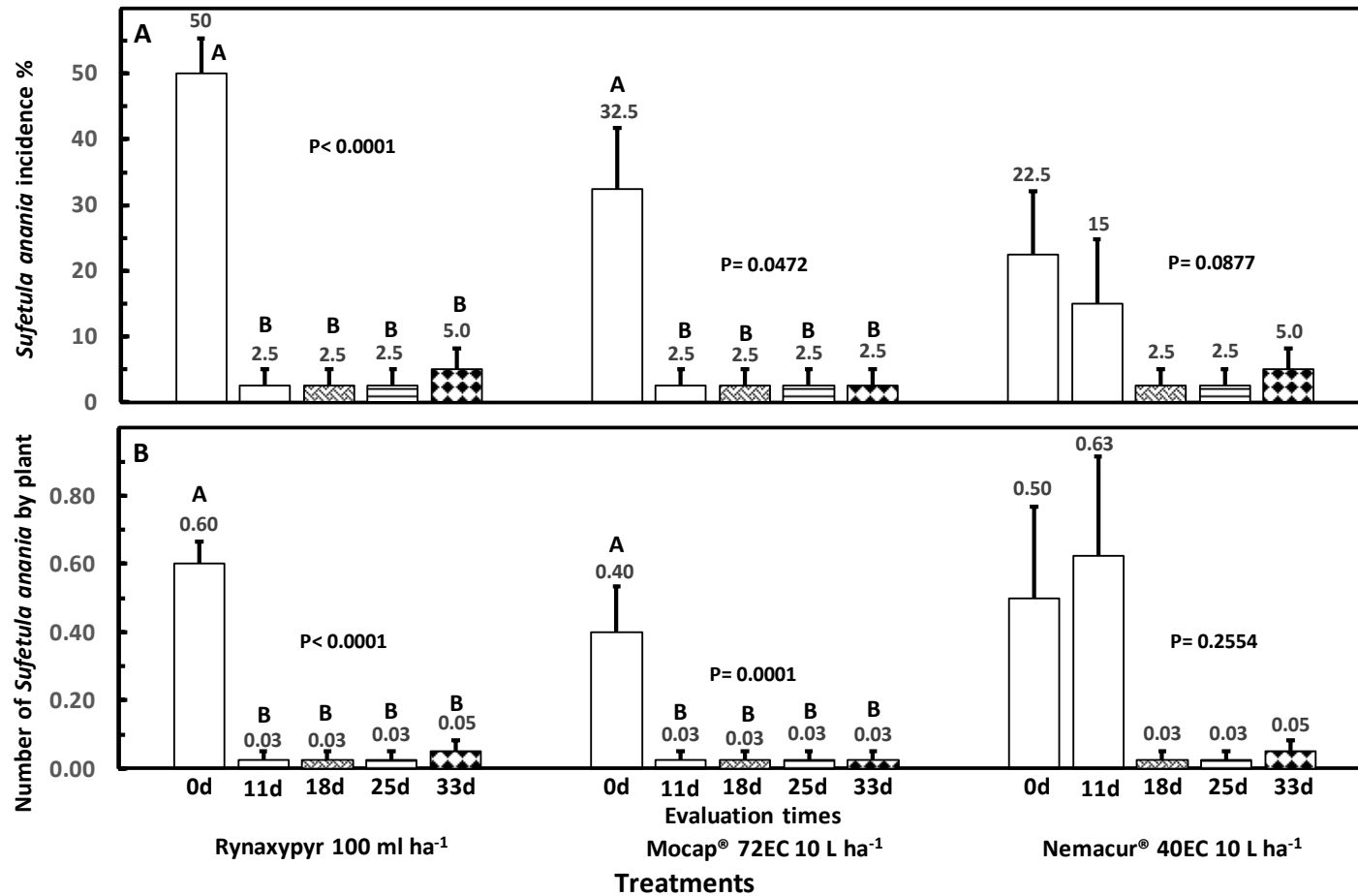


Figure.5 A-B. A) Incidence (%) and B) number of *Sufetula anania* by plant of pineapple (*Ananas comosus* MD-2) pre-application and post treatment with different products for its control. Pre-application 0 days: each bar is the mean \pm standard error of 8 replicates, x 11-18 days: each bar is the mean \pm standard error of 16 observations (two evaluations at 11 and 18 days and 8 replicates in each evaluation), x 11-25 days: each bar is the mean \pm standard error of 24 observations (three evaluations at 11, 18 and 25 days and 8 replicates in each evaluation) and x 11-33 days: each bar is the mean \pm standard error of 32 observations (four evaluations at 11, 18, 25 and 33 days and 8 replicates in each evaluation). In each replicate, five plants were evaluated. The probability over each group of bars compares the treatments.

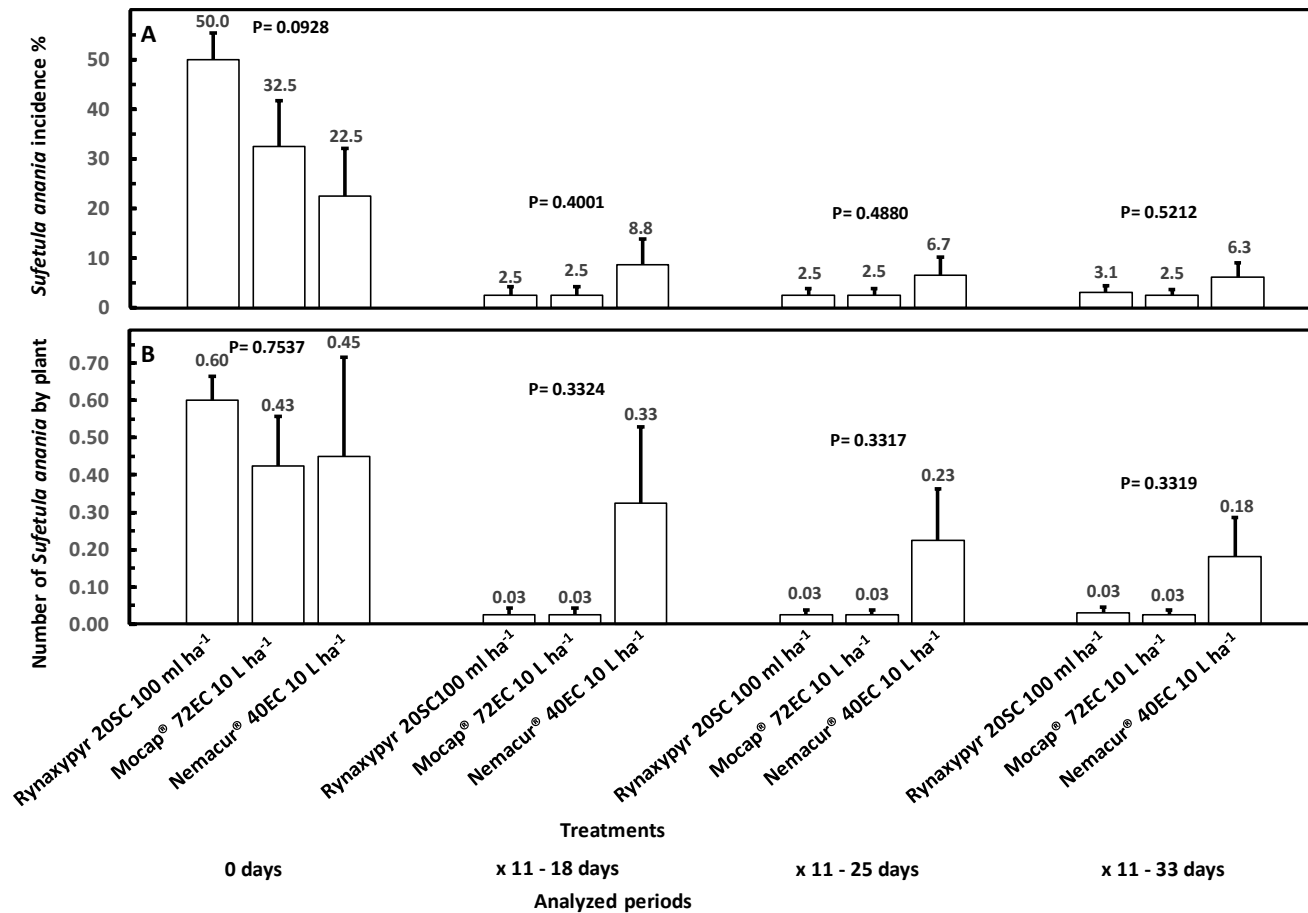
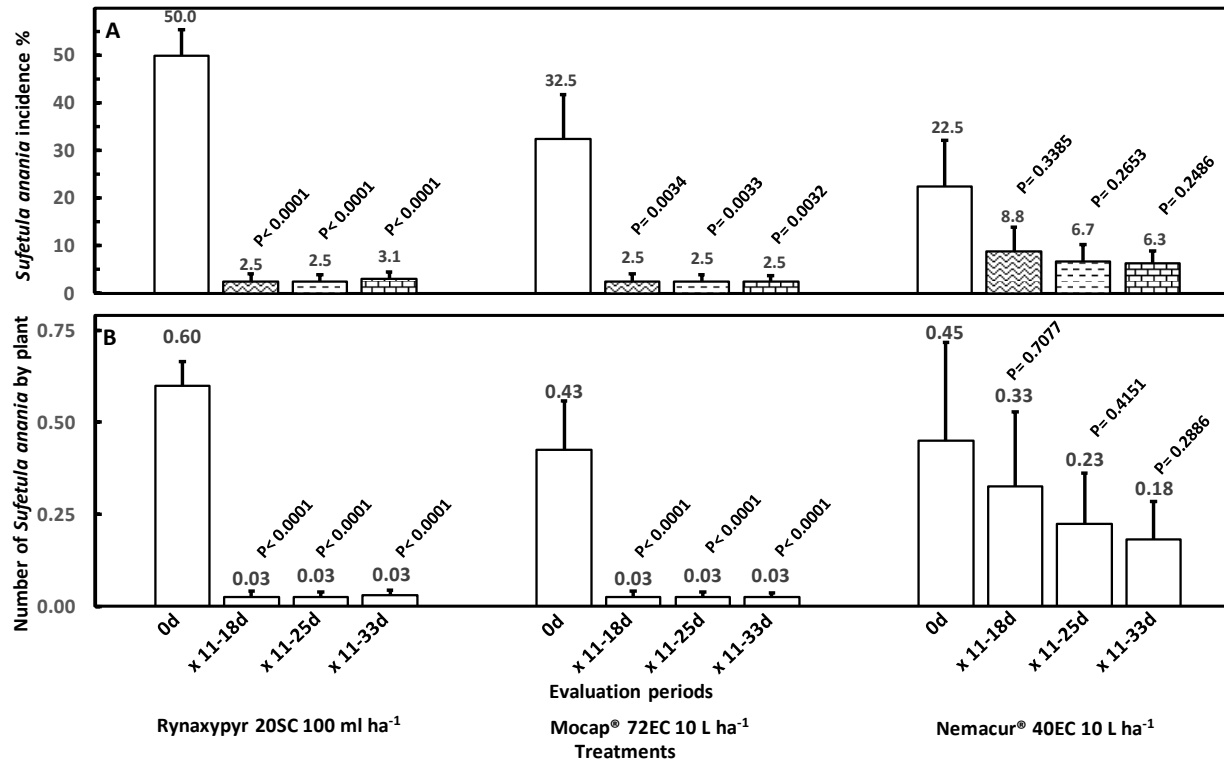


Figure.6 A-B. Product effect (pre-application comparison versus average of evaluations at 11-18; 11-18-25 days or average of evaluations at 11-18-25-33 days post application) on the incidence (A) and (B) number of *Sufetula anania* by plant of pineapple (*Ananas comosus* MD-2) that were treated with different products. At 0 days (0d) each bar is the mean \pm standard error of 8 repetitions, at x11-18d, which is the average of 11 and 18 days post application, each bar is the mean \pm standard error of 16 observations (2 evaluations at 11 and 18 days post application * 8 repetitions), at x11-25d, which is the average of 11, 18 and 25 days post application, each bar is the mean \pm standard error of 24 observations (3 evaluations at 11, 18 and 25 days post application * 8 repetitions) and at x11-33d, which is the average of 11, 18, 25 and 33 days post application, each bar is the mean \pm standard error of 32 observations (4 evaluations at 11, 18, 25 and 33 days post application * 8 repetitions) and in all evaluations, in each repetition the value is the average of 5 plants. The probability over the x11-18d, x11-25d and x11-33d bars correspond to the comparison of that average against the value at 0 days in each treatment.



The evaluated rates of Rynaxypyr of 80- and 120-mL ha⁻¹ in 3750 L of solution ha⁻¹ were very effective in controlling the pest up to 15 days after its application in the first experiment, and in the second experiment, where Rynaxypyr at 100 mL ha⁻¹ followed an application of Nemacur® 40EC, the good control was extended up to 33 days post application.

This leads to suggesting that to manage this pest, at least two consecutive applications are required with an interval of between 15 and 20 days, using products with different mode of action, in order to prevent infestation by successive invasions, since lepidoptera's life cycle is about 57 -70 days (Cruz and Obando, 2020; Méndez, 2024) and the four larval stages consume roots (Cruz and Obando, 2020). In presence of high *Sufetula anania* incidences or high number of larvae per plant, it is preferable to first apply the Rynaxypyr given its specificity for the pest and 21 days later treat with another insecticide like Mocap® 72EC or Nemacur® 40EC, both with a broad spectrum of control. To which product apply would depend on what another pest are present in the plantation.

It is known that Mocap® 72EC is effective for symphylids (Guillén *et al.*, 2025), white grub (Calvo *et al.*, 2016) and nematode control (Araya *et al.*, 2021; Rabie, 2017), and Nemacur® 40EC for mealybugs (Araya, 2019b), nematodes (Araya *et al.*, 2021; Rabie, 2017), and the weevil *Metamasius dimidiatipennis* y *M. hemipterus*. Considering that the pest is located on the roots within the soil, in the three products, the maximum rate registered on the product's label should be used. Knowing that Rynaxypyr and Nemacur® 40EC are systemic and that the adult pest is more active in the late afternoon and early evening, the application, including Mocap® 72EC, should preferably be carried out at that time, when the plant is also metabolically more active and there is a greater net absorption of CO₂ (Malézieux *et al.*, 2003). When applying Rynaxypyr, the addition of another insecticide, with contact action mechanism, could be appropriate to also get control of the adult lepidopter.

Author Contributions

German Prado: investigation, methodology, Oscar Cortes: methodology, investigation, validation, Juan Delgado: resources, methodology, reviewing, César Guillén: investigation, validation, reviewing, writing, Eduardo Corrales: analysis, writing, reviewing, Mario

Araya: investigation, writing original draft, reviewing and editing.

Data Availability

The datasets generated during and/or analyzed during the current study are available from the corresponding author on reasonable request.

Declarations

Ethical Approval Not applicable

Consent to Participate No applicable

Consent to Publish Not applicable

Conflict of Interest The authors declare no competing interests.

References

- Araya, M., Cortes, O., Salas, E. (2021). Entendiendo la problemática de los nematodos en piña (*Ananas comosus*). Revista Científica LIFE-RID: 66-79.
- Araya, M. (2019a). Chemical control of symphylids in pineapples. Acta Horticulturae.1239:167-172. <https://doi.org/10.17660/ActaHortic.2019.1239.20>
- Araya, M. (2019b). Chemical control of mealybugs in pineapples. Acta Horticulturae. 1239:147-152. <https://doi.org/10.17660/ActaHortic.2019.1239.18>
- Bacca, T., Cabrera, N. J., Gutiérrez, Y. (2021). Toxic effect of chlorantraniliprole on new-born larvae of the potato tuber moth *Tecia solanivora* (Lepidoptera: Gelechiidae). Annals of Applied Biology. Pp: 1-7. <https://doi.org/10.1111/aab.12688>
- Bonneau, X., Husni, M., Philippe, R., Somchit, N., Jourdan, G., Lubis, N. (2004). Discovery of a factor limiting yields in a coconut plantation on peat: the insect pest *Sufetula* spp. Exp. Agric. 40 (1), 53–64 <https://doi.org/10.1017/S0014479703001455>
- Bonneau, X., Husni, M., Beaudoin-Ollivier, L., Susilo, J. (2007). Controlling *Sufetula* spp.: a coconut insect pest on peat soils. Exp. Agric. 43 (3), 289–299 <https://doi.org/10.1017/S0014479707005017>.

- Calvo, J., Vargas, J., Araya, M. (2016). Control químico de *Phyllophaga* en caña de azúcar (*Saccharum officinarum*). 10º Congreso ATALAC, 31 agosto al 2 setiembre, Veracruz, México. 13p.
- Cameron, R. A., Williams, C. J., Portillo, H. E., Marcon, P. C., Teixeira, L. A. (2015). Systemic application of chlorantraniliprole to cabbage transplants for control of foliar-feeding lepidopteran pests. Crop Protection 67:13-19. <http://dx.doi.org/10.1016/j.cropro.2014.09.009>
- Cline, H. (2007). New worm control insecticide first with systemic properties. Farm Press Editorial Staff. Western Farm Press, timely, reliable information for California – Arizona Agriculture. 2p.
- Cordova, D., Benner, E. A., Sacher, M. D., Rauh, J. J., Sopa, J. S., Lahm, G. P., Selby, T. P., Stevenson, T. M., Flexner, L., Gutteridge, S., Rhoades, D. F., Wu, L., Smith, R. M., Tao, Y. (2006). *Anthranilic diamides*: A new class of insecticides with a novel mode of action, ryanodine receptor activation. Pesticide Biochemistry and Physiology. 84: 196-214. <https://doi.org/10.1016/j.pestbp.2005.07.005>
- Cortes, M. O. (2021). Larva de raíz afecta cultivos piñeros. Piña de Costa Rica, Edición 39 2021–2.p. 21.
- Cruz, S. A. E., Obando, M. J. D. (2020). Identificación, ciclo de vida y control ex-situ de larvas de raíz (*Acrolophus texanellus*) (Lep:Acrolopidae) y (*Sufetula anania*) (Lep.: Crambidae) asociados al cultivo de piña (*Ananas comosus* var. *comosus*) MD-2 en Costa Rica. Trabajo final de graduación, Instituto Tecnológico de Costa Rica, sede San Carlos. 289p.
- Devine, G. J., Eza, D., Ogusuku, E., Furlong, M. J. (2008). Uso de insecticidas: contexto y consecuencias ecológicas. RevPeruMedExp Salud Publica 25(1):74-100.
- Flint, D. R. (1977). Chemical evidence for systemic nematocidal activity of NemaCur. Pflanzenschutz-Nachrichten Bayer 30:153-163.
- Garita, C. R. A. (2014). La Piña. 1st edición (Cartago: Editorial Tecnológica de Costa Rica, Instituto Tecnológico de Costa Rica), pp.568.
- Guzmán, H. T. J., Varela, B. I., Hernández, V. S., Durán, M. J., Montero, C. W. (2014). Principales géneros de nematodos fitoparásitos asociados a plátano y piña en las regiones Huetar Norte y Huetar Atlántica de Costa Rica. Tecnol. Marcha 27 (1), 85–92. <https://doi.org/10.18845/tm.v27i1.1699>.
- Guillén, C., Corrales, E., Delgado, J., Cortes, O., Araya, M. (2025). Evaluation of products for pineapple (*Ananas comosus* MD-2) symphyllids control. Int. J. Curr. Microbiol. App. Sci 14(2):144-152. <https://doi.org/10.20546/ijcmas.2025.1402.013>
- Hannig, G. T., Ziegler, M., Marçon, P. G. (2009). Feeding cessation effects of chlorantraniliprole, a new anthranilic diamide insecticide, in comparison with several insecticides in distinct chemical classes and mode-of-action groups. Pest Manag. Sci. 65 (9), 969–974 <https://doi.org/10.1002/ps.1781>. PubMed
- Hayden, J. E. (2013). *Sufetula* Walker in Florida (Lepidoptera: crambidae). InsectaMundi 0296, 1–15 <https://digitalcommons.unl.edu/insectamundi/801>
- Herrera, D., Paniagua, F., Abarca, J., Cortes, O., Delgado, J., Araya, M. (2024a). Effect of Coragen on pineapple (*Ananas comosus* MD-2) *Sufetula anania* control. Acta Horticulturae 1402: 99-106. <https://doi.org/10.17660/ActaHortic.2024.1402.14>
- Herrera, D., Paniagua, F., Abarca, J., Cortes, O., Delgado, J., Araya, M. (2024b). Incidence and distribution of *Sufetula anania* on pineapple (*Ananas comosus* MD-2). Acta Horticulturae 1402:107-112. <https://doi.org/10.17660/ActaHortic.2024.1402.15>
- Jasmine, R. S., Rajendran, B., Rani, R. K. (2012). BIPM components for the management of borer complex in sugarcane. JBiopest 5 (Supplementary):209-211.
- Lahm, G. P., Stevenson, T. M., Selby, T. P., Freudenberger, J. H., Cordova, D., Flexner, L., Bellin, C. A., Dubas, C. M., Smith, B. K., Hughes, K. A., Hollinshaus, G., Clark, C. E., Benner, E. A. (2007). Rynaxypyr™: a new insecticidal anthranilic diamide that acts as potent and selective ryanodine receptor activator. Bioorganic & Medicinal Chemistry Letters 17:6274-6279. <http://dx.doi.org/10.1016/j.bmcl.2007.09.012>
- Lahm, G. P., Cordova, D., Barry, J. D. (2009). New and selective ryanodine receptor activators for insect control. Bioorganic & Medicinal Chemistry 17: 4127-4133. <https://doi.org/10.1016/j.bmc.2009.01.018>
- Malezieux, E., F. C 'ote, and D. P. Bartholomew, 2003. "Crop environment, plant growth and

- physiology,” in the Pineapple: Botany, Production and Uses, D. P. Bartholomew, R. E. Paull, and K. G. Rohrbach, Eds., pp. 69–108, CABI, Wallingford, UK, 3rd edition.
- Ministerio de Agricultura y Ganadería, Servicio Fitosanitario del Estado (2019). Manual de Buenas Prácticas Agrícolas para la Producción Sostenible del Cultivo de la Piña (*Ananas comosus* L.) 88p.
- Méndez, L. W. (2024). Biología y ecología del barrenador de las raíces *Sufetula anania* (Lepidoptera:Crambidae) en el cultivo de piña en la zona norte de Costa Rica. Tesis sometida a la consideración de la Comisión del Programa de Posgrado en Ciencias Agrícolas y Recursos Naturales para optar al grado y título de Maestría Académica en Ciencias Agrícolas y Recursos Naturales con énfasis en Protección de Cultivos. Universidad de Costa Rica. 61p.
- Monge, M. M. (2018). Guía para la Identificación de las Principales Plagas y Enfermedades en el Cultivo de Piña. Universidad de Costa Rica, CICA (MAG, Servicio Fitosanitario del Estado), pp.44.
- Rabie, E. C. (2017). Nematode pests of pineapple. Pp:395-497. In: Fourie, H., Spaull, V. W., Jones, R. K., Daneel, M. S., De Waele, D. Eds. Nematology in South Africa: A view from the 21 Century.
- Roberts, R. T. and Hutson, H. D. (1999). Metabolic pathways of agrochemicals. Part 2: Insecticides and fungicides. The Royal Society of Chemistry. 1475p.
- Rodríguez, M. M. (2011) (sf). Guía de Identificación y Manejo Integrado de Plagas y Enfermedades en Piña. (Proyecto REP-Car Banacol), pp.58.
- Rogers, E. F., Koniuszy, F. R., Shavel, J. J., Folkers, K. (1948). Plant insecticides. I. Ryanodine, a new alkaloid from *Ryania speciosa* Vahl. J. Am. Chem. Soc. 70(9):3086-3088.
<https://doi.org/10.1021/ja01189a074>
- Seín, F. (1930). The sugar cane root caterpillar and other new root pests in Puerto Rico. The Journal of the Department of Agriculture of Puerto Rico 14 (3), 167–191.
<https://doi.org/10.46429/jaupr.v14i3.14222>
- Solis, M. A., Shaffer, M. (1999). Contribution towards the study of the Pyralinae (Pyralidae): historical review, morphology, and nomenclature. J. Lepid. Soc. 53 (1), 1–10.
- Solis, M. A., Hayden, J. E., Vargas, S. F., Gonzales, F., Sanabria, U. C., Gulbranson, C. J. (2019). A new species of *Sufetula* Walker (Lepidoptera: Crambidae) feeding on the roots of pineapple, *Ananas comosus* (L.) (Bromeliaceae), from Costa Rica. Proceedings of the Entomological Society of Washington 121(3):497-510.
<https://doi.org/10.4289/0013-8797.121.3.497>
- Sujayanand, G. K., Pandey, S., Bandi, S. M. (2021). Efficacy of Coragen 20 SC against lepidopteran pest in greengram and its compatibility with *Bacillus thuringiensis* isolates. Legume-Research- An International Journal 44(12):1521-1528. <https://doi.org/10.18805/LR-4481>
- Teixeira, L. and Andaloro, J. T. (2011). Diamide insecticides: global efforts to address insect resistance stewardship challenges. Pesticide Biochemistry and Physiology 106(3):76-78.
<http://dx.doi.org/10.1016/j.pestbp.2013.01.010>
- Vargas, C. E. (2011). Guía para la identificación y manejo integrado de plagas en piña. REPCAR PROAGROIN. 29P.
- Zeck, W. (1971). The systemic nematicidal potential of Nemacur. Pflanzenschutz-Nachrichten Bayer24:114-140.

How to cite this article:

German Prado, Oscar Cortes, Juan Delgado, César Guillén, Eduardo Corrales and Mario Araya. 2025. Chemical Control of *Sufetula anania* on Pineapple (*Ananas comosus* MD-2). *Int.J.Curr.Microbiol.App.Sci*. 14(05): 104-118.
doi: <https://doi.org/10.20546/ijemas.2025.1405.011>